needed at either wheel, and then the isolation valves **70***a* and **70***b* pulsed open to achieve independently controlled pressures needed to slow down the respective wheel. The braking force at each wheel would be controlled by cooperative modulation of the respective isolation valves **70***a* and **70***b*, and the dump valves **72***a* and **72***b*. In another control arrangement which is contemplated, the isolation valves **70***a* and **70***b* would not be initially closed, but would be closed when the associated wheel began to slow, or when the desired brake pressure was reached. In yet another control scheme which is contemplated, the proportional control valve **51** would modulate pressure in the brakes as needed to achieve the pressure needed for both of the brakes **11***a* and **11***b*, with both the isolation valves **70***a* and **70***b* remaining open at all times, and both of the dump valves **72***a* and **72***b* remaining shut. This would be simple control, but may result in a brake **11***a* or **11***b* which did not need as high a brake pressure as the other of the brakes **11***a* and **11***b* being braked with greater pressure than needed to prevent wheel spin. Therefore it is also contemplated that the proportional control valve **51** would be modulated to control the wheel spin on the wheel operating on the surface with the lower coefficient of friction, while the isolation valves **70***a* or **70***b* and the dump valves **72***a* or **72***b* would be modulated to control the brake pressure of the other wheel, on a surface with higher coefficient of friction, at the appropriate lower pressure needed to stop the wheel spin. Thus it is apparent that the arrangement of the brake system **350** provides for great flexibility in a traction control situation. The same is true in other braking situations, such as when antilock braking is required.

As an example, if a need was detected for pulsing the vehicle brakes **11***a* and *b* such as would be required to prevent locking up the brakes, or for braking in slippery road conditions, the isolation valves **70***a* and **70***b* and the dump valves **72***a* and **72***b* could be pulsed open and closed. The digital (either on or off) nature of control of the isolation valves **70***a* and **70***b* and the dump valves **72***a* and **72***b* allows the isolation valves **70***a* and **70***b* and the dump valves **72***a* and **72***b* to cooperate to rapidly increase, decrease, or hold pressure for antilock braking. Other non-modulated or digital applications of the front brake system **351** could be effected as needed with the arrangement of the isolation and dump valves **70***a*, **70***b*, **72***a*, and **72***b* as shown. Note that it is anticipated that the isolation valves **70***a* and **70***b* and the dump valves **72***a* and **72***b* may be suitably constructed to provide proportional control of hydraulic brake fluid passing through the respective valve, thereby permitting finer control of the hydraulic pressure in the brakes **11***a* and **11***b*. For example, the isolation valves **70***a* and **70***b* may be constructed to enable the valve to operate in a stable manner when the valve is partially open, allowing a more gradual pressure rise in the associated brake **11***a* and **11***b*, which may be desired if the wheel is near lock-up. The dump valves **72***a* and **72***b* could similarly be constructed to modulate flow of hydraulic brake fluid therethrough.

As in the previous embodiments of the brake system **2**, **200** and **300**, upon failure of the normal source of pressurized hydraulic brake fluid **4** to the vehicle brakes **11***a* and **11***b*, or upon failure of the control module, the backup source **6** of pressurized hydraulic brake fluid supplied by the master cylinder **12**, will be an available source of pressurized hydraulic brake fluid to be applied to the brakes of the brake system **350**, preferably to the front brakes **11***a* and **11***b* as illustrated in FIG. **10**. The vehicle brakes **11***a* and **11***b* supplied by the master cylinder **12** can be designed to provide sufficient braking force to safely operate the vehicle with the pressure supplied from the master cylinder **12**. Of course, although not illustrated in FIG. **10**, it is contemplated that the master cylinder **12** can be operatively connected to selectively supply pressurized hydraulic brake fluid to the power cylinders **210** and **212**, if desired. It is also contemplated that separate power supplies may by used to power the motors of the power cylinders **210** and **212** to provide an additional level of redundancy and safety to the brake system **350**. Of course redundant, independently powered, and cross-checking control modules may be utilized to control the operation of the power cylinders **210** and **212**, and of the proportional control valves **51***a* and **51***b*. It is also contemplated that all four of the vehicle brakes **11***a, b, c,* and *d* could be supplied from a respective power cylinder similar to the power cylinder **210**. The backup source **6** could be connected to two or four of the vehicle brakes **11***a, b, c,* and *d*. A suitable fluid separator unit **54***a* is preferably provided between the power cylinder and the connection of the backup source **6** in communication with the vehicle brakes **11***a, b, c,* and *d*.

The principle and mode of operation of this invention have been explained and illustrated in its preferred embodiment. However, it must be understood that this invention may be practiced otherwise than as specifically explained and illustrated without departing from its spirit or scope.

What is claimed is:

1. A brake system comprising:

a normal source of pressurized hydraulic brake fluid;

a backup source of pressurized hydraulic brake fluid;

a vehicle brake which is operated by application of pressurized hydraulic brake fluid thereto;

a valve for selectively preventing the flow of hydraulic brake fluid between the backup source and said vehicle brake; and

a fluid separator unit for maintaining the integrity of said backup source of pressurized fluid and preventing intermixing of the hydraulic brake fluid of said normal source and the hydraulic brake fluid of said backup source and having a movable pressure boundary which enables, through movement thereof, said normal source of pressurized hydraulic brake fluid to selectively act upon said vehicle brake via a portion of said backup source when said valve is shut.

2. The brake system of claim **1**, further including a brake system brake demand detection arrangement comprising:

a manually operated master cylinder;

a fluid conduit in fluid communication with said master cylinder;

a pedal simulator in fluid communication with said master cylinder via said fluid conduit, said pedal simulator including a spring and a piston acting to compress said spring under the influence of pressurized hydraulic fluid from said master cylinder exceeding a first pressure;

a pressure transducer generating a signal representative of the pressure of said fluid flowing between said master cylinder and said pedal simulator; and

an expansion volume unit in fluid communication with said master cylinder and said pedal simulator via said fluid conduit, said expansion volume unit permitting fluid to flow from said master cylinder into said expansion volume unit when said fluid exceeds a second pressure less than said first pressure.

3. The brake system of claim **2** wherein said pedal simulator further includes a housing defining a bore having

a first end adapted to be connected in fluid communication with said backup source, said bore further having a second end, said piston being slidably disposed in said bore and having a first face and a second face, said spring engaging said second face of said piston and acting between said piston and a portion of said housing to urge said first face of said piston toward said first end of said bore, and a damping circuit hydraulically interposed between said first end of said bore and said backup source to present a first cross sectional flow area to fluid flowing from said backup source through said damping circuit into said housing, and presenting a second cross sectional flow area to fluid flowing from said housing through said damping circuit, the ratio of said second cross sectional flow area to said first cross sectional flow area being greater than unity.

4. The brake system of claim 3 wherein said ratio is less than 10:1.

5. The brake system of claim 4 wherein said ratio is in the range of 2:1 to 4:1.

6. The brake system of claim 3 further including a relief valve opening above a predetermined pressure to permit fluid flow through said relief valve from said brake system to said housing.

7. The brake system of claim 6 wherein said predetermined pressure is in the range of about 5 bar to about 30 bar.

8. The brake system of claim 3 further including a relief valve opening above a predetermined pressure to permit fluid flow through said relief valve from said brake system to said housing.

9. The brake system of claim 8 wherein said predetermined pressure is in the range of about 5 bar to about 30 bar.

10. The brake system of claim 2 wherein said fluid separator unit has a housing defining a cylinder bore and a piston slideably disposed therein, said piston having a first working face in fluid communication with said normal source and a second working face in fluid communication with said backup source, said first and second working faces having substantially similar areas.

11. The brake system of claim 2, further including:

a brake pedal for operating said master cylinder;

a pedal travel sensor for generating a stroke signal representative of the stroke of said brake pedal;

said signal from said pressure transducer being related to the brake application force applied by a driver to said brake pedal;

a control unit responsive to a demand signal for controlling said brake system actuator, said demand signal being generated as a blended function of both said stroke signal and said signal from said pressure transducer wherein, during an initial movement of said brake pedal, said stroke signal is weighted greater than said signal from said pressure transducer, and wherein, during a subsequent movement of said brake pedal, said signal from said pressure transducer is weighted greater than said stroke signal.

12. The brake system of claim 1 further including a pedal simulator, said pedal simulator comprising:

a housing defining a bore having a first end adapted to be connected in fluid communication with said backup source, said bore further having a second end;

a piston slidably disposed in said bore and having a first face and a second face;

a spring engaging said second face of said piston and acting between said piston and a portion of said housing to urge said first face of said piston toward said first end of said bore; and

a damping circuit hydraulically interposed between said first end of said bore and said backup source to present a first cross sectional flow area to fluid flowing from said backup source through said damping circuit into said housing, and presenting a second cross sectional flow area to fluid flowing from said housing through said damping circuit, the ratio of said second cross sectional flow area to said first cross sectional flow area being greater than unity.

13. The brake system of claim 12 wherein said ratio is less than 10:1.

14. The brake system of claim 13 wherein said ratio is in the range of 2:1 to 4:1.

15. The brake system of claim 12 further including a relief valve opening above a predetermined pressure to permit fluid flow through said relief valve from said brake system to said housing.

16. The brake system of claim 15 wherein said predetermined pressure is in the range of about 5 bar to about 30 bar.

17. The brake system of claim 1 wherein said fluid separator unit has a housing defining a cylinder bore and a piston slideably disposed therein, said piston having a first working face in fluid communication with said normal source and a second working face in fluid communication with said backup source, said first and second working faces having substantially similar areas.

18. A brake system comprising:

a brake pedal for operating a brake system actuator;

a pedal travel sensor for generating a stroke signal representative of the stroke of said brake pedal;

a brake system sensor for generating a force signal representative of the brake application force applied by a driver to said brake pedal;

a control unit responsive to a demand signal for controlling said brake system actuator, said demand signal being generated as a blended function of both said stroke, signal and said force signal wherein, during a first part of the stroke of said brake pedal, said stroke signal is weighted greater than said force signal, and wherein, during a second part of the stoke of said brake pedal, said force signal is weighted greater than said stroke signal.

19. An electro-hydraulic brake system comprising:

a reservoir of hydraulic brake fluid;

a pump having a suction port and a discharge port, said suction port being connected in fluid communication with said reservoir;

a first fluid conduit being connected in fluid communication with said discharge port of said pump;

a fluid separator unit having a housing with a bore defined therethrough, said bore having a first end and a second end, said first end of said bore being connected in fluid communication with said discharge port of said pump via said first fluid conduit, said fluid separator unit further including a piston slidingly disposed in said bore and a spring disposed to urge said piston toward said first end of said bore;

a second fluid conduit connected in fluid communication with said second end of said fluid separator unit;

a vehicle brake connected in fluid communication with said second end of said fluid separator unit via said second fluid conduit;

a third fluid conduit connected in fluid communication with said vehicle brake;

a hydraulic master cylinder connected in fluid communication with said vehicle brake via said third fluid conduit;

an electrically-operated valve disposed in said third fluid conduit, said valve preventing the flow of hydraulic brake fluid between said master cylinder and said vehicle brake when closed, said valve being open to permit the flow of hydraulic brake fluid between said master cylinder and said vehicle brake when said valve is electrically deenergized;

a fourth fluid conduit connected in fluid communication with said master cylinder and said third fluid conduit;

a pedal simulator connected in fluid communication with said master cylinder via said fourth fluid conduit;

an second electrically-operated valve disposed in said fourth fluid conduit, said second valve being closed to prevent the flow of hydraulic brake fluid between said master cylinder and said pedal simulator when said second valve is deenergized, said second valve permitting the flow of hydraulic brake fluid between said master cylinder and said pedal simulator when said second valve is open; and

a damping circuit hydraulically interposed between said master cylinder and said pedal simulator, said damping circuit comprising, in parallel flow paths, an orifice and a check valve such that said damping circuit presents a first cross sectional flow area to fluid flowing from said master cylinder through said damping circuit into said pedal simulator, and presenting a second cross sectional flow area, different from said first cross sectional flow area, to fluid flowing from said pedal simulator to said master cylinder through said damping circuit.

20. The electro-hydraulic brake system of claim **19** further including a third electrically-operated valve disposed in said first fluid conduit, said third valve preventing fluid communication between said pump and said fluid separator unit when said third valve is closed, said third valve permitting fluid communication between said pump and said fluid separator unit when said third valve is open, the electro-hydraulic brake system further including fifth fluid conduit having a first end connected in fluid communication with said first fluid conduit and said fluid separator unit and having a second connected in fluid communication with said reservoir, the electro-hydraulic brake system further including a fourth electrically-operated valve disposed in said fifth fluid conduit, said fourth valve preventing fluid communication between said fluid separator unit and said reservoir when said fourth valve is closed, said fourth valve permitting fluid communication between said fluid separator unit and said reservoir when said fourth valve is open.

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